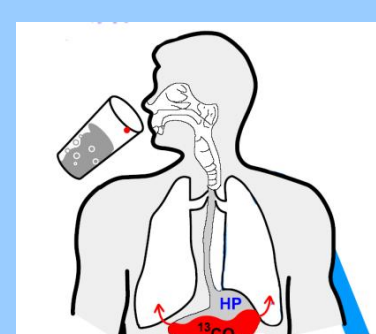


QCL Based Multiple-Gas Spectroscopy on a Single Platform

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Motivation: Sensitive and selective monitoring platform



Early detection of diseases.



Leak detection



Air Quality monitoring



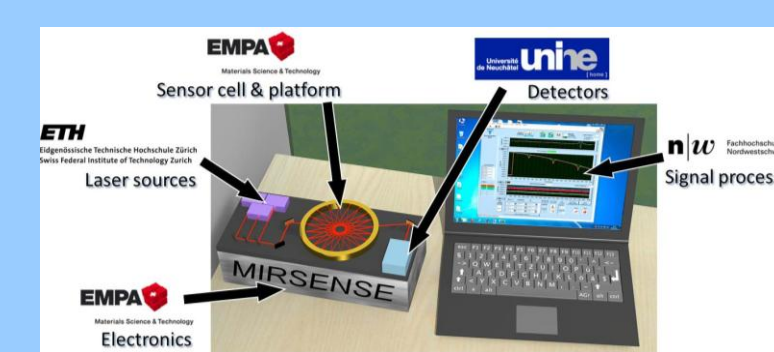
Industrial Process monitoring

Goal: Single spectroscopic platform for the 10 most important atmospheric pollutants and green house gases.



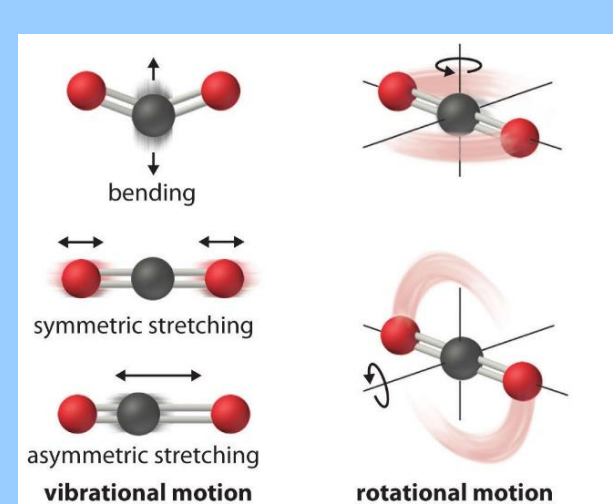
Current air pollution monitor (NABEL Station) in EMPA, Dübendorf

trace gas	typical concentration (ppb)	main relevance	standard method	Price (CHF)	Weight (kg)	Power (W)
NH ₃ (ammonia)	2-20	pollutant	Denuder/CRODS	55	30	200
O ₃ (ozone)	5-200	pollutant	UV abs	12	15	150
CH ₄ (methane)	1700	greenhouse gas	GC-FID	25	25	300
H ₂ O (water vapor)	331	greenhouse gas	GC-ECD	25	30	500
SO ₂ (sulfur dioxide)	0.1-10	pollutant	UV Fluorescence	18	20	170
NO ₂ (nitrogen dioxide)	1-100	pollutant	chemilum. conc. + CLD	25	25	300
NO (nitrogen monoxide)	1-100	pollutant	chemilum. conc. + CLD	25	25	300
CO (carbon monoxide)	1-10	pollutant	NDIR	16	15	150
CO ₂ (carbon dioxide)	380	greenhouse gas	NDIR	25	8	50
H ₂ O (water vapor)	0.2-4%	greenhouse gas	NDIR	25	8	50

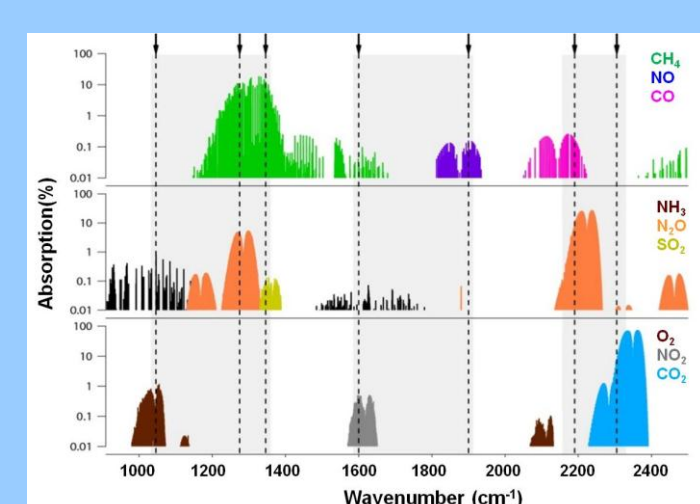


Monitoring platform under current plan

Method: Mid-Infrared Spectroscopy

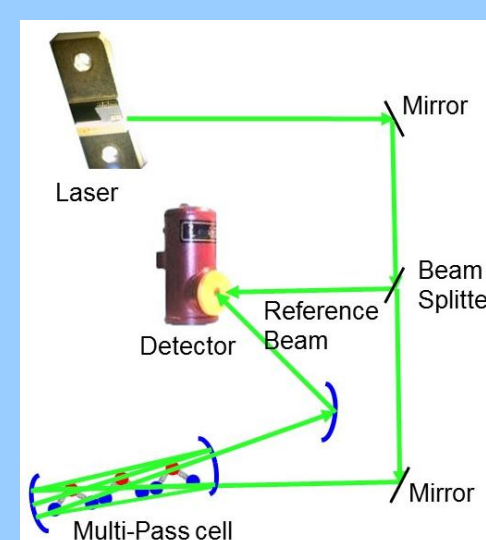


Rotational Vibration modes of molecules



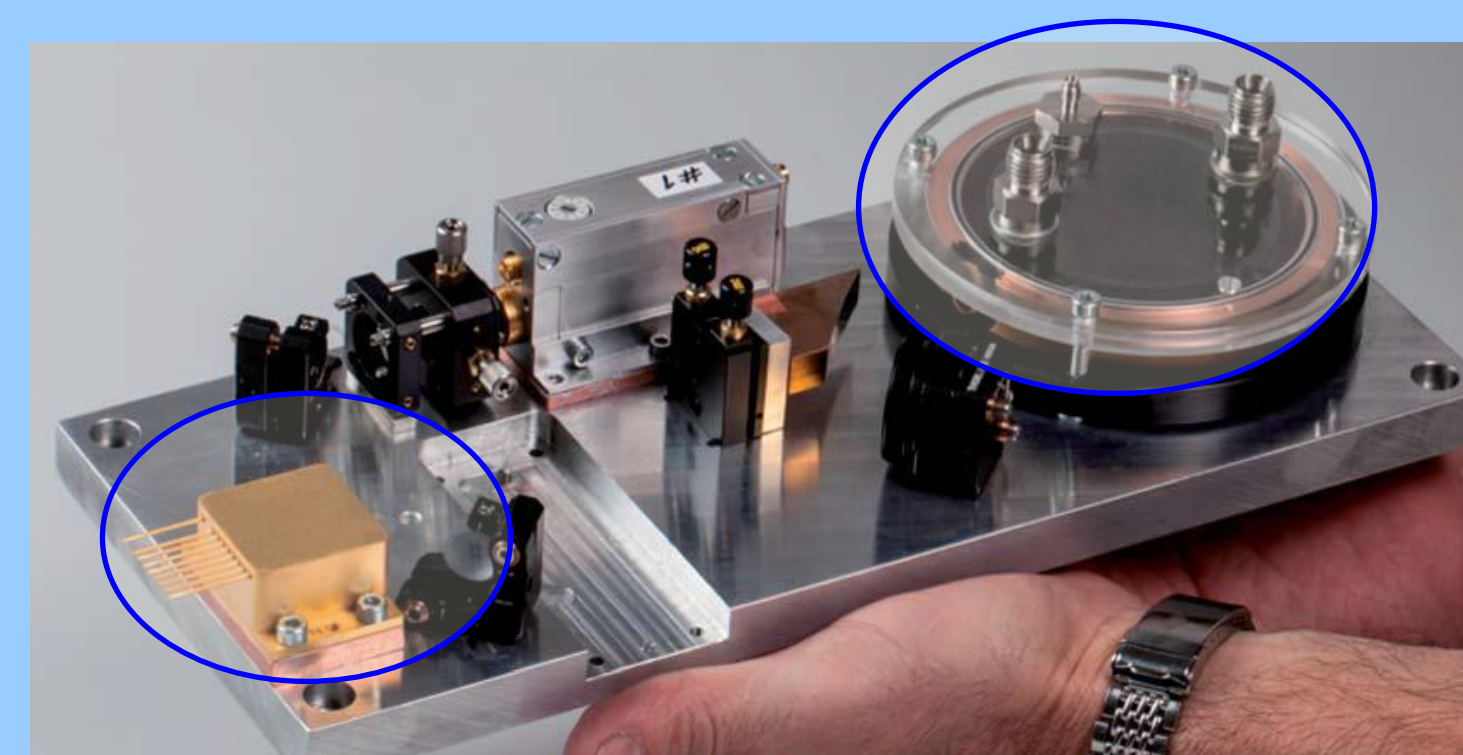
Strongest absorption fingerprints => Mid-Infrared range

Set-up



1. Tuning of the laser emission across the fingerprint region
2. Measure how much light is absorbed by the sample

Miniaturized Platform



Quantum Cascade Lasers (QCLs) in Mid-IR

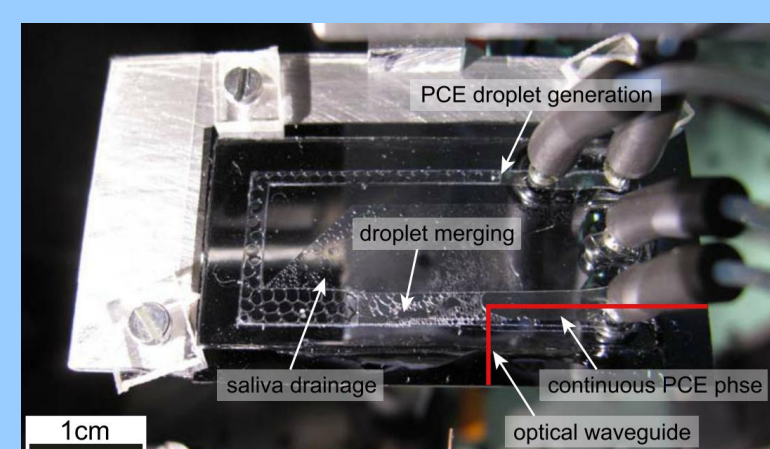
- Powerful
- Compact

Toroidal Mirror Cell

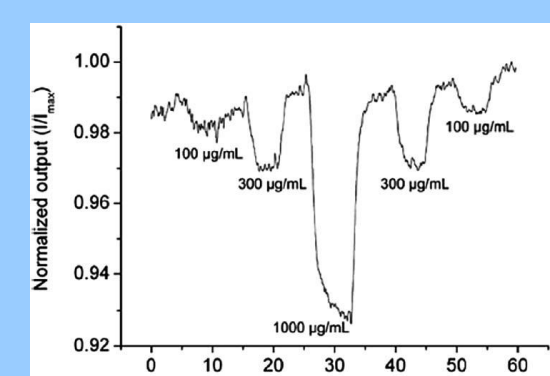
- Large Optical-Length/Volume ratio
- Good sensitivity (15ppb NO₂).
- Less expensive than state of the art multi-pass cells

Electronics - Real-time fitting engine directly linked to HITRAN database

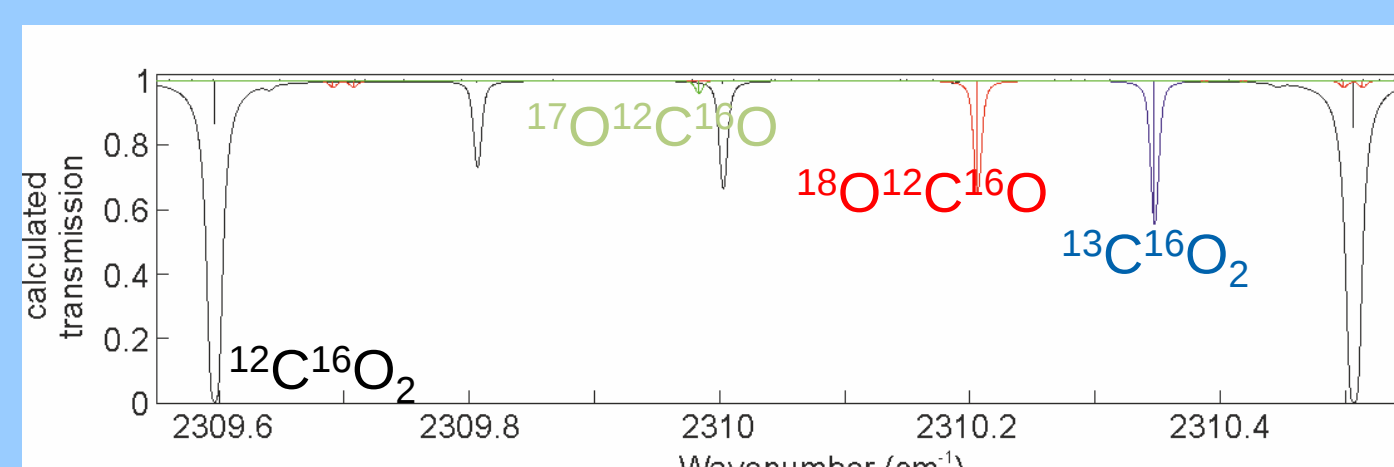
Achievements



Laboratory based CO₂ isotope analyzer

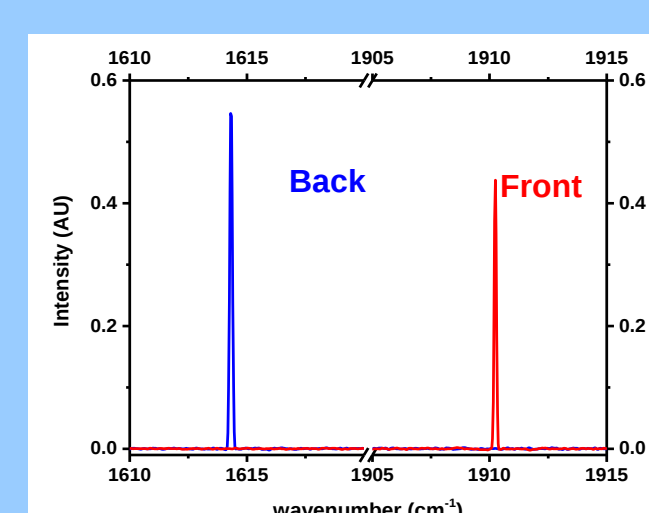
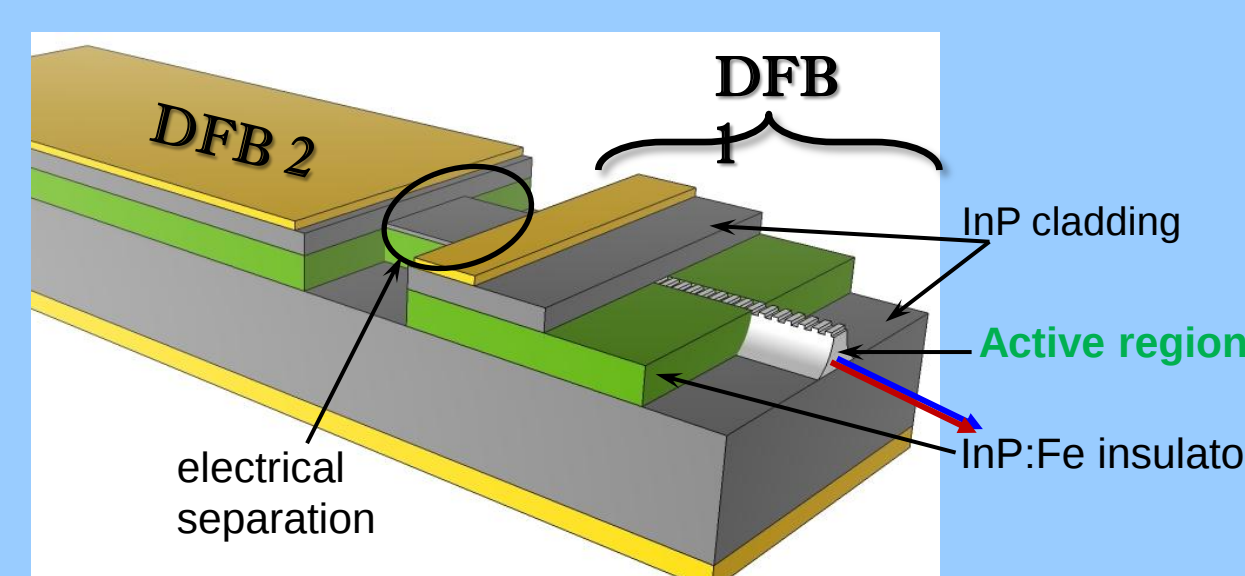


Sensitive measurement of Cocaine in PCE solvent

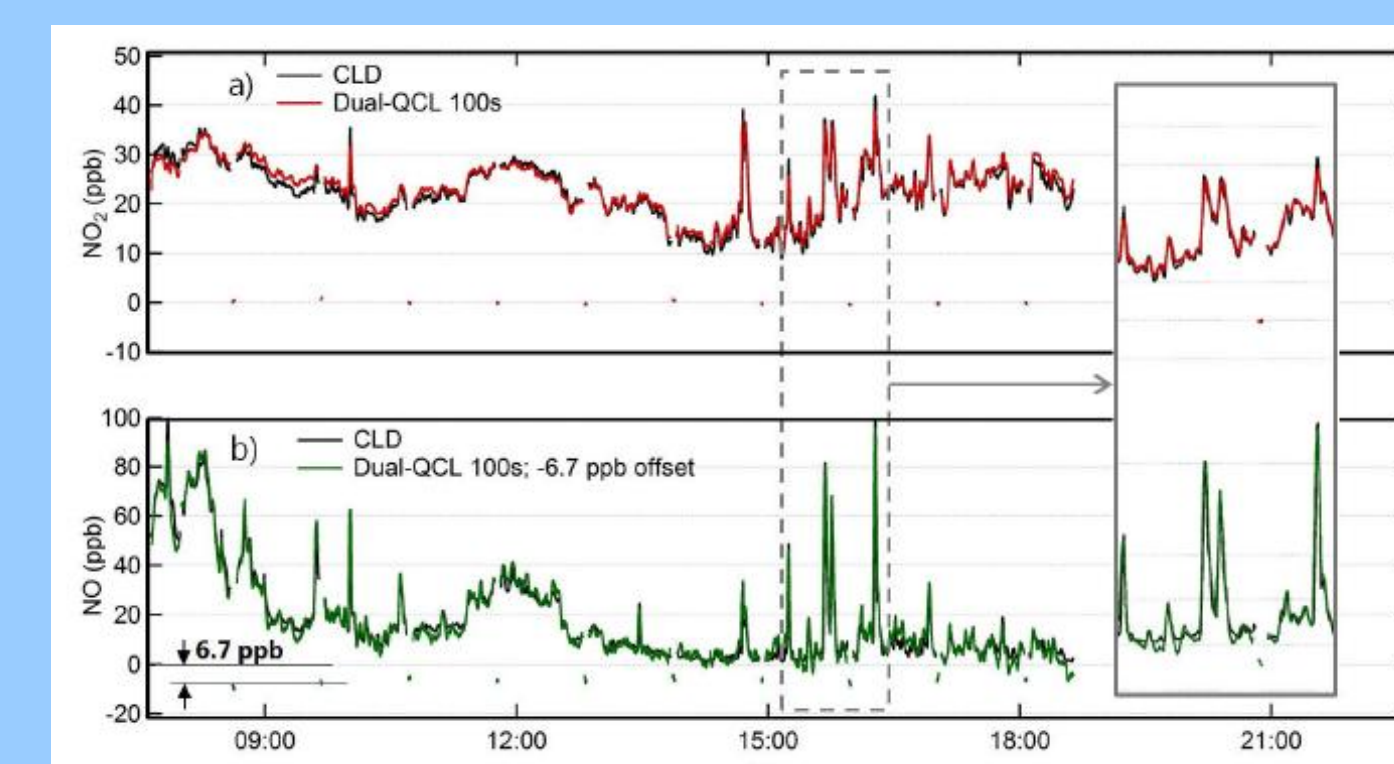


Miniaturized Platform for NO₂ measurements

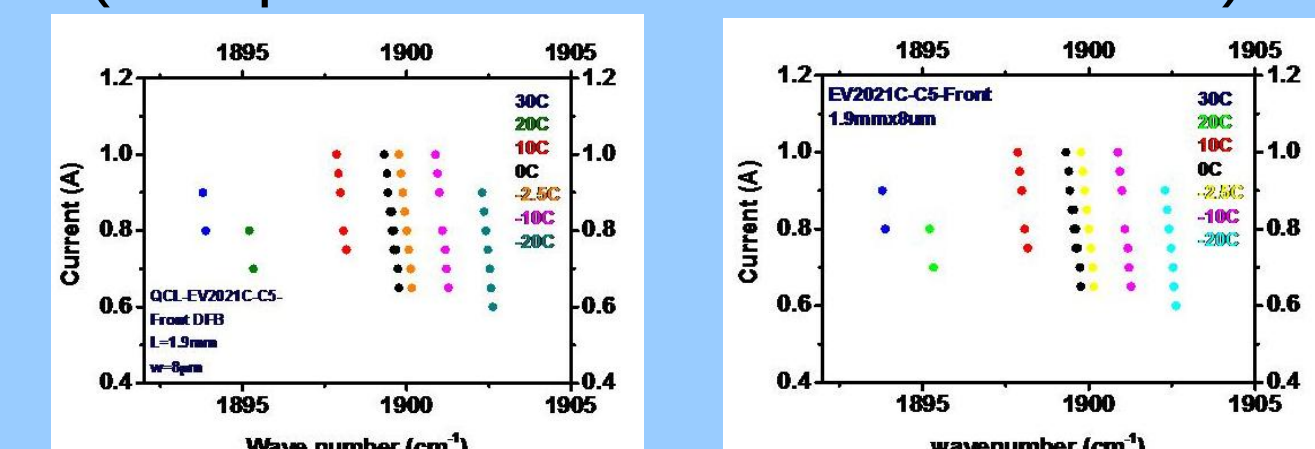
Dual-wavelength QCLs



Single mode and two wavelength QCL fabricated

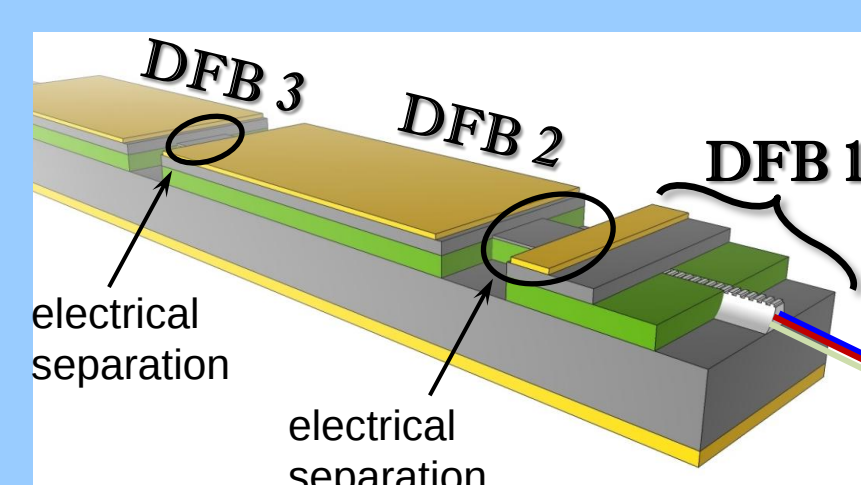


Simultaneous NO/NO₂ measurements (Compared with Chemiluminescence)

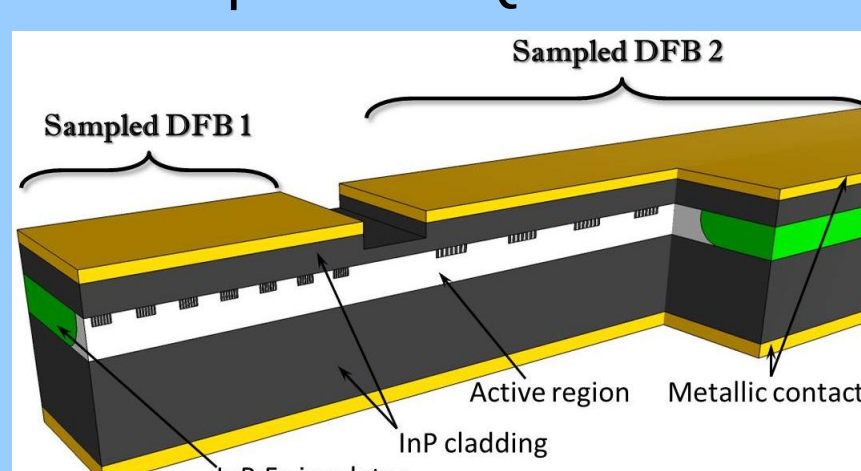


Tunable over the 1600/1900cm⁻¹ range of interest for NO/NO₂ spectroscopy

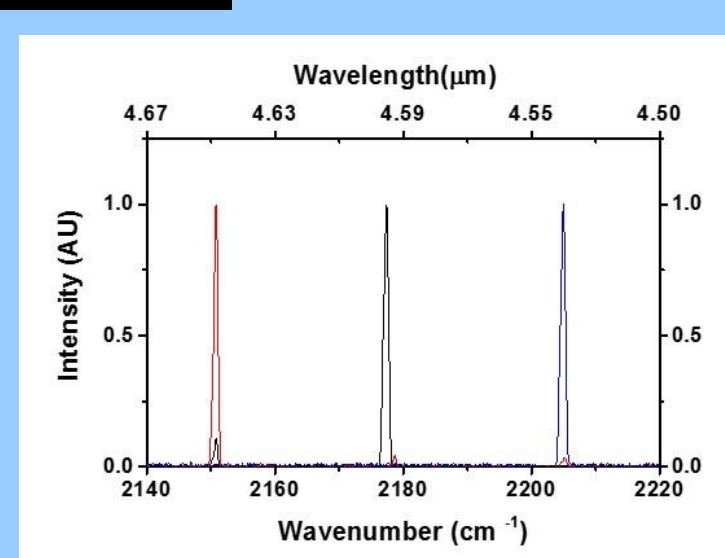
In Progress – Triple Color QCLs



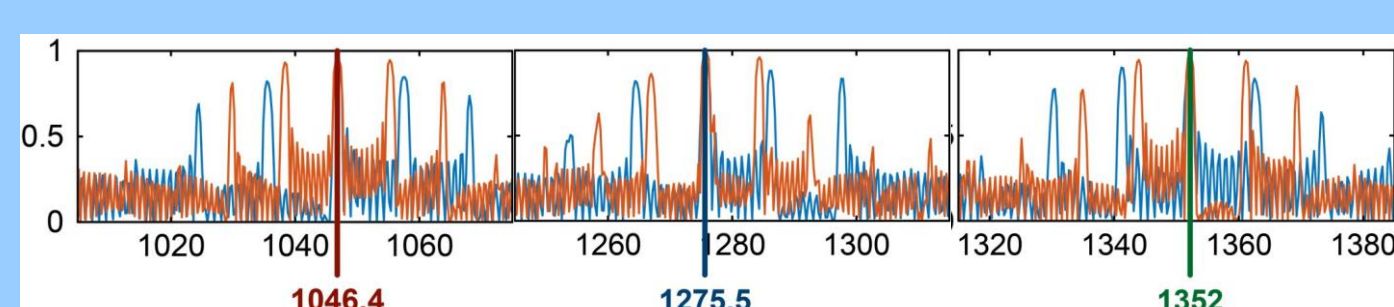
Triple DFB QCLs



Sampled Grating (SG) DFBs



Proof Of Concept Demonstrated



QCL active region and SG DFB design complete and fabrication in progress

IRSens II Team



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